

# THE “PSEUDO SINGLE ROW” RADIATOR DESIGN

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## LITERATURE REVIEW

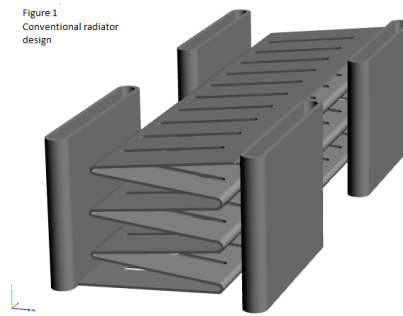
*Radiator is a device used to cool internal combustion engine by radiating heat out via a fluid called coolant which is being circulated around the engine.*

*Current generation radiators consist of two header tanks placed on bottom and top interlinked by a passage of tubes, which are flattened in order to maximize the surface area. It is made up of brass or copper soldered to brass headers, but to save money aluminum tubes with plastic headers may also be used.*

*The coolant is circulated by a centrifugal pump, which forces cooled coolant around the engine block where it absorbs the engine heat. This results in the expansion of the fluid causing the pressure to increase in the system. A pressure valve is provided which in case of excess pressure will allow the out flow of some fluid in exchange of some air thus maintaining pressure.*

*The size of radiator is determined by the need of heat dissipation during the peak heat generation periods keeping in account the heat dissipation during idle speed conditions.*

*Now in the convention radiator design there is need to have some spaces between the tubes so as to add sufficient ligament in the head part so as to join the header with the flattened tubes. This results in a loss of thermal performance as the conduction across the tubes and to the fins is hindered.*



### ABSTRACT

This paper puts forth a new improved radiator design that may be used in place of the current radiator design. The multi row radiator tubes have spaces between them to accommodate sufficient ligament in order to join the tubes with the head. The average size of this ligament in commercial application is 5mm to 10mm.

This design has some limitations such as there is no contact surface between the tube rows so the conduction of heat is hindered; as a result the rate of heat conduction to the fins and across the tube rows decreases.

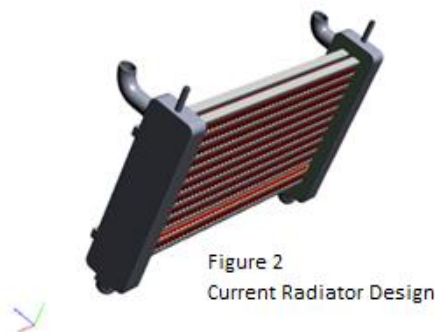
Other than this the current design has limited tube wall thickness. If the conventional tube wall thickness is beyond the maximum allowable value, then it would tend to distort, resulting in disturbed fin-tube bond, and hence the performance is affected. So the tube thickness and hence the performance is limited in the current design.

Now a way to circumvent the above limitation is fill up of the space with some material with light weight, good heat conduction in such a way that it does not undermines the structural integrity. The material will act as a superstructure which not only provides additional structural strength, but also increases the surface area for heat radiation, the heat flow across the tubes and to the fins would increase so as a result the design would be more efficient.

This May Be Regarded As Pseudo – Single Row Radiator Design.

### CURRENT RADIATOR DESIGN AND ITS PERFORMANCE

The design of a standard radiator consists of two header tanks placed on bottom and top/ sides interlinked by a passage of flattened tubes such that the surface area is maximum and these passages form the core area of heat exchange. This network is typically called multi row radiator core and is made up of brass, aluminum or copper soldered to metallic headers. (As shown in figure 2)



## FLOW SIMULATION REPORT

Solid works was used to simulate the flow in the heat exchanger. The units were kept in SI system with external analysis type.

*The Size of computational domain is as follows*

X min	-0.412 m
X max	0.412 m
Y min	-0.387 m
Y max	0.384 m
Z min	-0.346 m
Z max	0.353 m

The Basic Mesh dimensions i.e. the number of cells in X, Y and Z was 38, 36 and 39 respectively.

Additional physical calculation options were

Heat Transfer Analysis: Heat conduction in solids: On  
Heat conduction in solids only: Off

Flow Type: Laminar and turbulent

Time-Dependent Analysis: Off

Gravity: On

Radiation: Of

Default Wall Roughness: 0 micrometer

In the material settings the fluids selected were air and water. And in solids copper and mild steel were used.

### ***Inlet conditions***

The static pressure was 101325 Pa with temperature 293.20K. The velocity vector was kept zero in all directions. Under the solid parameters the default material was copper with its initial temperature 293.20K.

The turbulence intensity was kept at 0.10% and the turbulence length 3.200e-004 m.

### ***Boundary conditions***

Type: Inlet mass flow

Coordinate system: Global coordinate system

X axis was selected as reference axis with mass flow rate 0.0010, temperature 500K and the boundary layer type turbulent.

The environmental pressure at temperature 500K was 101325.00 Pa

### ***Surface Goals***

The system was set to calculate the average value of the fluid temperature with convergence on

### ***Results***

Average temperature of outlet fluid is 345.69K.

## The “Pseudo Single Row” Radiator Design

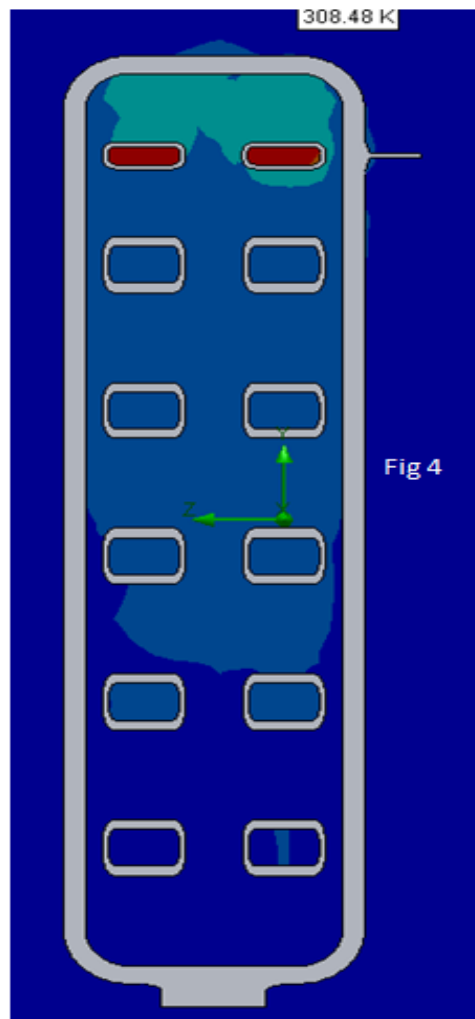
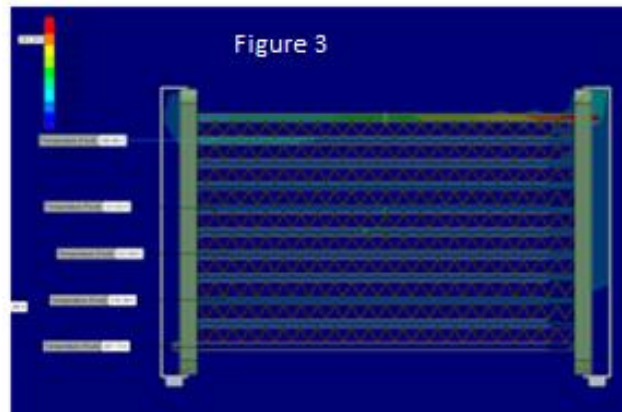
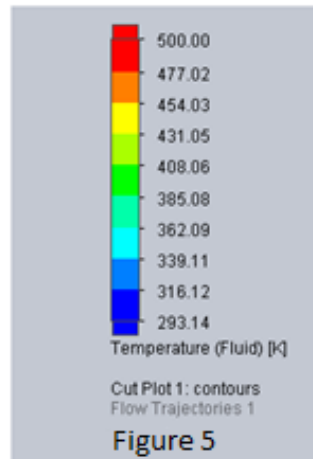


Figure 3 and 4 displays the temperature variation across the radiator body with color distribution described below in figure 4



## Appendix

### Air

Path: Gases Pre-Defined

Specific heat ratio ( $C_p/C_v$ ): 1.399

Molecular mass: 0.0290 kg/mol

### Water

Path: Liquids Pre-Defined

Cavitation effect: Yes

Temperature: 0 K

Saturation pressure: 0 Pa

### Solids

#### Copper

Path: Solids Pre-Defined\Metals

Density: 8960.00 kg/m<sup>3</sup>

Conductivity type: Isotropic

Electrical conductivity: Conductor

Radiation properties: No

Melting temperature: Yes

Temperature: 1356.20 K

#### Steel (Mild)

Path: Solids Pre-Defined\Alloys

Density: 7870.00 kg/m<sup>3</sup>

Specific heat: 472.0 J/(kg\*K)

Conductivity type: Isotropic

Thermal conductivity: 51.9000 W/(m\*K)

Electrical conductivity: Conductor

Resistivity: 1.7400e-007 Ohm\*m

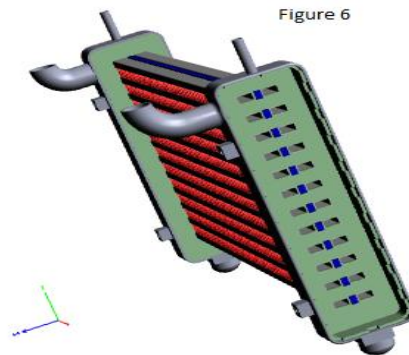
Radiation properties: No

Melting temperature: Yes

Temperature: 1673.15 K

## PROPOSED RADIATOR DESIGN AND ITS PERFORMANCE

In the proposed design of the radiator metal stripes have been added between the tubes of the radiator. These metal plates are illustrated in the Fig 6 with blue color.



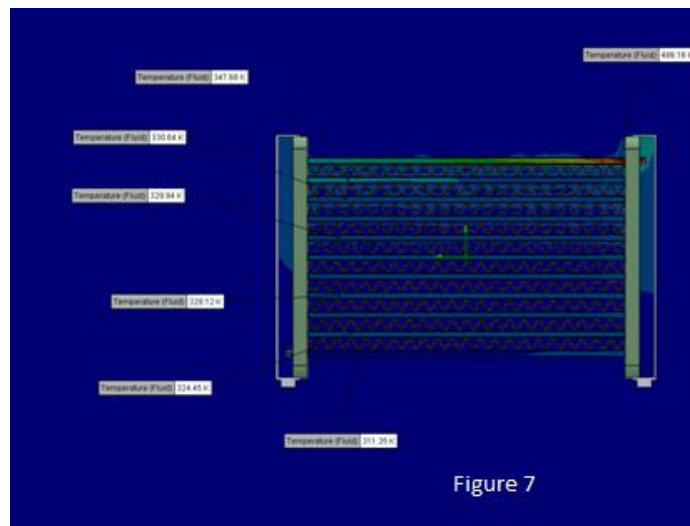
### Flow simulation report

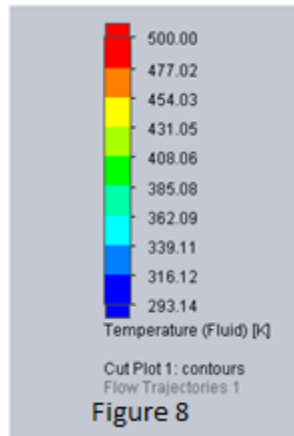
Solid works was used to simulate the flow in the heat exchanger. The settings were kept same as the previous simulation.

### Results

Average temperature of outlet fluid is 338.28K

Figure 7 displays the temperature variation across the radiator body with color distribution described below in fig 8





## Appendix

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Resistivity: 1.7400e-007 Ohm\*m

Radiation properties: No

Melting temperature: Yes

Temperature: 1673.15 K

## CONCLUSION AND FUTURE SCOPE

The net temperature of the water coming out of the standard temperature is 345.69 K, whereas the temperature of water in the improved design is found out to be at 338.28K. So for the same radiator dimensions the cooling effect has been improved by 1.428%. This figure can further be improved if material of greater thermal conductivity is used as the filling material. Moreover the air drag resistance will also decrease in the new design, improving the resultant efficiency.

## REFERENCE

- [1] The “Tube Touching” Multi-row radiator design.
- [2] Ralph L. Webb Pennsylvania State University
- [3] Manjunath S N, S.S.Mahesh Reddy and Saravana Kumar, Numerical Investigation of Automotive Radiator Louvered Fin Compact Heat Exchanger, *International Journal of Mechanical Engineering and Technology*, 5(7), 2014, pp. 01-04.